Instruction Manual
21-50Jc

for the use of

Major™ Megger® Insulation Testers

GENERAL ELECTRIC COMPANY
INSTRUMENTATION & COMMUNICATION
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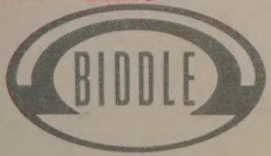

James G. Biddle Co.
PLYMOUTH MEETING, PA. 19462

21-50Jc

Instruction Manual

for the

Major Megger Insulation Testers

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Figure A: The Cat. No. 21159, with Case and Test Leads.

Section I

GENERAL INFORMATION

1-1 EQUIPMENT ILLUSTRATION (See Figure 1).

a. GENERAL. The series of Major Megger(R) Insulation Testers described in this manual is composed of a hand-driven ac generator or transformer or both with voltage rectified to 100, 250, 500 and 1000 volts dc; a cross-coil movement with 0-20,000Ω and 0-1000 MΩ scales, a carrying case, and test leads. The six-position selector switch is marked: DISCHARGE, 1000V MΩ x 2, 500V MΩ x 1, 250V MΩ ÷ 2, 100V MΩ ÷ 5, and Ω.

b. PURPOSE. The instrument measures the resistance, in megohms, to the flow of current through and/or over the surface of electrical equipment insulation. The test results are used to detect the presence of dirt, moisture, and insulation deterioration. The instrument also measures resistances up to 20,000 ohms.

1-2 FUNCTIONAL DESCRIPTION

a. GENERAL. The instrument is portable. It is enclosed in a case which stands on four rubber feet.

The ohmmeter movement is mounted at one end of the instrument, opposite to the test terminals or binding posts marked GUARD (crank side), LINE (the center terminal), and GROUND.

The crank for the hand-driven generator is mounted on the right side. A window is provided at the top to permit reading of the two scales. The instrument is transported in a vinyl carrying case.

The power cord is attached to one end (line operated model), or plugged into the left side for a dual-operated unit. Line-operated instruments have a power switch on the end. The dual-operated instrument also has the power switch, plus a "LINE-CRANK" selector switch.

b. OHMMETER. The ohmmeter movement is of the permanent magnet cross-coil pointer type with two scales - ohms and megohms.

The megohm scale length: 2.50" approximate, (63.5 mm).

The ohm scale length: 2.375" approximate (60.3 mm).

The instrument is calibrated to have an accuracy of ±0.03" (.76 mm) from any marked position.

The instrument to be cranked at 160 RPM, minimum.

1-3 QUICK REFERENCE DATA

a. MAXIMUM DIMENSIONS:

(1) Length: 7.0 inches, (177.8 mm).

(2) Width: 4.5 inches, (114.3 mm).

6.0 inches, including handle (152.4 mm).

(3) Height: 5.0 inches, (127 mm).

b. OPERATING TEMPERATURE: 0^{o} to 65^{o} C, 32^{o} to 149^{o} F

c. VOLTAGE, OPEN CIRCUIT, AT 160 RPM

Minimum cranking speed: 1000V to 1050V dc
500V to 550V dc
250V to 275V dc
100V to 110V dc

d. RESISTANCE RANGES, MAXIMUM:

0-20000MΩ at 1000V,
0-20000 Ω

e. ACCURACY: ±0.030 inch, (.76 mm).

f. VOLTAGE CHANGE AT INFINITY BETWEEN CRANKING SPEEDS OF 160-240 RPM is ±3%.

g. MODELS

Cat. No. 21159 Hand-Cranked Generator

Cat. No. 21259	Line-Operated 120V 50/60 Hz.
Cat. No. 21359	Dual-Operated, Hand-Cranked or Line-Operated 120V 50/60 Hz.
Cat. No. 21259-47	Line-Operated 240V 50/60 Hz.
Cat. No. 21359-47	Dual-Operated, either Hand-Cranked or Line-Operated 240V 50/60 Hz.

1-4 SAFETY PRECAUTIONS

- SAFETY IS THE RESPONSIBILITY OF THE USER -

- LA SEGURIDAD ES EL CARGO DEL OPERADOR -

The Test Set and the sample to which it is connected are a source of high-voltage electrical energy and all persons making or assisting in the tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and associated circuits.

Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit unless the set is de-energized and all parts of the test circuit are grounded.

Any persons not directly associated with the work must be kept away from test activities by suitable barriers, barricades or warnings.

If the set is properly operated and all grounds correctly made, no rubber gloves are necessary. As a routine safety procedure, however, some users require the use of rubber gloves, not only in making connections to the high-voltage terminals, but in manipulating the controls. The James G. Biddle Co. considers this to be an excellent safety practice.

1-5 RECEIVING INSTRUCTIONS

Your Megger instrument has been thoroughly tested and inspected to rigid inspection specifications before being shipped and is

ready for use after it is set up as indicated in the Installation section. Check the equipment received against the packing list. Notify James G. Biddle Co., Plymouth Meeting, Pa. of any shortage of materials. The Megger instrument should be examined for damage received in transit. If any damage is found, file a claim with the carrier at once and notify James G. Biddle Co. or its nearest representative giving a detailed description of the damages observed.

1-6 WARRANTY

All products supplied by the James G. Biddle Co. are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps or tubes, where the original manufacturer's warranty shall apply.
WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

1-7 REPAIR

The James G. Biddle Co. maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

Section 2

INSTALLATION

2-1 UNPACKING AND HANDLING

To prepare the instrument for use, remove outer wrapping and lift out of the carrying case, along with the test leads.

2-2 INSTALLATION

The instrument is a portable unit used only for testing purposes and no permanent installation is necessary.

2-3 INSPECTION AND ADJUSTMENT

Use the instrument by positioning it on a firm and fairly level surface. Do not use near large masses of iron or within magnetic fields.

NOTE: THE INSTRUMENT IS NOT EQUIPPED WITH EXTERNAL POINTER ZEROING, BECAUSE THE MOVEMENT IS A TRUE OHMMETER, THE POINTER WILL REST ANYWHERE ON THE SCALE.

a. CHECK ∞ (INFINITY). With no leads connected to the binding posts, check infinity by energizing the instrument. This may be done by hand cranking at 160 RPM minimum, or, if line operated, plugging in the unit and turning it on. The pointer should read infinity when switch is set to any position except Ω or discharge within an accuracy of ±0.030".

b. CHECK 0 (ZERO). Short circuit GROUND and LINE binding posts. Energize the instrument. The pointer should read ZERO when switch is set at any position except discharge within an accuracy of ±0.030".

c. CHECKING TEST LEADS. With test leads connected to GROUND and LINE binding posts and with opposite ends separated, energize the instrument. If the pointer indicates more than .030" less than infinity there is a leak between the leads which must be removed before the instrument can be used. Touch the test ends of the leads together while energized and make a zero reading to be sure the leads are not open-circuited.

Section 3

OPERATOR'S SECTION

3-1 FUNCTIONAL OPERATION. See Manual 21J for additional instructions.

a. USE. The instrument is to be used in checking the insulation resistance of electrical installations and components. These tests are to be made for acceptance and test of equipment, for maintenance checks, or to determine faulty wiring.

b. CAPABILITIES AND LIMITATIONS. The instrument is designed to make insulation resistance tests between:

0- 200 megohms at 100 volts
0- 500 megohms at 250 volts
0-1000 megohms at 500 volts
0-2000 megohms at 1000 volts

The potential applied to the apparatus under test will vary from zero to maximum voltage depending on the resistance of the item being tested and the internal resistance of the instrument that is in series with the GROUND binding post, (see figure 6-1).

WARNING! DO NOT USE INSTRUMENT ON APPARATUS FOR WHICH THE MAXIMUM TEST VOLTAGE IS UNSAFE.

c. OHMMETER MOVEMENT. (See figure 6-8). Is of the permanent magnet, moving cross coil and pointer type with a scale length of about 2.5 inches. It is calibrated to within ±0.030 inch of any marked position. The ohm scale length is about 2.375 inches.

d. TEST LEADS. Test leads are provided with the instrument; any convenient length may be used. The test leads have jack termination at one end for attaching to the instrument's binding posts, and at the opposite strong spring clips for connecting to the equipment or circuit under test.

3-2 PREPARATION FOR USE. Before using instrument, check zero and infinity and check test leads. Follow procedure outlined in paragraph 2-3.

3-3 PREPARING APPARATUS TO BE TESTED.

a. Shut down apparatus.

b. Open switches.

c. De-energize.

WARNING! WHEN TAKING APPARATUS OUT OF SERVICE, BLOCK OUT DISCONNECT SWITCHES, APPLY NEUTRAL OR PROTECTIVE (WORKMAN'S) GROUNDS.

d. Disconnect apparatus from other equipment and circuits. Avoid removing protective grounds by disconnecting the equipment from the exposed bus or line, leaving the latter grounded.

e. If neutral or other ground connections must be disconnected, ascertain that they are not carrying current at the time, and that when disconnected no other equipment will lack necessary protection.

f. Inspect conductors which lead away from the circuit being tested to be sure that they have been disconnected properly from any source of voltage.

g. Inspect apparatus to be tested in order to determine what equipment is connected and will be included in the test. The more equipment included in the test, the lower the reading will be, and the true insulation resistance of the equipment under test may be masked by the insulation resistance of the associated equipment.

h. Capacitive effect on readings: on initial tests capacitive feedback will cause oscillation of the pointer until dissipated. If re-test is required the equipment under test should be discharged for 4 times the length of the initial test to ensure accurate readings, i.e., if test is for a period of one minute, discharge for 4 minutes.

i. When apparatus is shut down for the insulation resistance test, make sure that the readings are not affected by leakage over or through switches or fuse blocks, etc. Such leakage may cause inaccurate test results. Inconsistent readings can be caused by current leaking from an energized line into the apparatus particularly if the live line is direct current. Such leakage can be detected by watching the ohmmeter pointer at the moment the test leads are connected to the equipment to be tested.

3-4 CONNECTIONS. See details in Instruction Manual 21J.

Section 4

PRINCIPLES OF OPERATION

4-1 OVERALL FUNCTIONAL DESCRIPTION

The instrument consists of an indicator calibrated directly in ohms and megohms and an ac generator with gear train or transformer with rectifying and resistance networks. A fold-away crank is provided for operating the generator.

4-2 FUNCTIONAL SECTIONS

a. INDICATOR. The indicator is of the permanent magnet cross-coil type. When current and voltage are applied to the indicator, the pointer deflects. The amount of deflection is determined by the circuit components and the unknown resistance.

b. GENERATOR. The alternating-current generator consists of a single stator coil and a bi-pole permanent magnet rotor. It is rectified to direct current through a voltage doubler rectifying circuit. The rotor operates in bearings which are permanently lubricated.

c. GEAR TRAIN. The gear train is a simple spur gear drive. Proper lubrication of the gear train is made by the manufacturer and no additional lubrication is required.

d. RESISTANCE NETWORK. Figure 6-1 shows schematic diagram of instrument.

4-3 CALIBRATION

a. TEST EQUIPMENT. (see Table 5-3).

b. OHM SCALE. To check ohm scale, proceed as follows: (proper cranking speed 160 RPM minimum, see Section 2-3b):

CAUTION! INSTRUMENT MUST BE DE-ENERGIZED WHEN CHANGING SAMPLES.

1. Set selector switch to Ω.

2. Connect 100Ω resistor across the GROUND AND LINE binding posts.

3. Energize the instrument (crank or turn on power switch).

4. Read Ω scale. Pointer should indicate 100Ω ±0.030". De-energize instrument (stop cranking or turn off switch), disconnect 100Ω resistor.

5. Repeat steps (2) and (4) with resistors of 500Ω, 5KΩ, and 20KΩ.

c. MEGOHM SCALE. To check megohm scale, proceed as follows, (proper cranking speed 160 RPM minimum):

CAUTION! INSTRUMENT MUST BE DE-ENERGIZED WHEN CHANGING SAMPLES.

1. Connect one-megohm resistor across the GROUND and LINE binding posts.

2. Set selector switch to 1000V MΩ x 2.

3. Energize the instrument (crank or turn on power switch).

4. Read MΩ scale. Pointer should indicate 0.5 ±0.030".

5. De-energize instrument (stop cranking or turn off switch).

6. Set selector switch to 500V MΩ x 1.

7. Energize the instrument.

8. Read MΩ scale. Pointer should indicate 1.0 MΩ ±0.030".

9. De-energize instrument.

10. Set selector switch to 250V MΩ ÷ 2.

11. Energize the instrument.

12. Read MΩ scale. Pointer should indicate 2.0 MΩ ±0.030".

13. De-energize the instrument.

14. Set selector switch to 100V MΩ ÷ 5.

15. Energize the instrument.

16. Read MΩ scale. Pointer should indicate 5.0 MΩ ±0.030".

17. De-energize the instrument.

18. Repeat above with resistor at 10 MΩ, 1000 MΩ.

19. Tabling the above (1) to (18) inclusive:

Selector Switch	STANDARD RESISTORS 1 MΩ (All scales reading ±0.030".)	10 MΩ	100 MΩ	1000 MΩ
1000 V MΩ x 2	.5 MΩ	5 MΩ	50 MΩ	500 MΩ
500 V MΩ x 1	1.0 MΩ	10 MΩ	100 MΩ	1000 MΩ
250 V MΩ ÷ 2	2.0 MΩ	20 MΩ	200 MΩ	---
100 V MΩ ÷ 5	5.0 MΩ	50 MΩ	500 MΩ	---

NOTE: IN REFERENCE TO b. and c., THE STANDARD RESISTORS THAT WERE SELECTED COVER MANY POINTS OF THE Ω AND MΩ SCALES, BUT OTHER RESISTORS OF DIFFERENT VALUES CAN BE USED TO MEET A PARTICULAR REQUIREMENT OR NEED.

d. DISCHARGE

1. Set selector switch to discharge.

2. Connect an ohmmeter with suitable ohm scale to the GROUND and LINE binding posts.

3. Read the ohmmeter scale. Resistance should be 112 kΩ ±1 .

e. VOLTAGE

1. Set selector switch to 1000 V MΩ x 2.

2. Connect electrostatic voltmeter across GROUND and LINE binding posts.

3. Energize the instrument.

4. Read voltmeter. Should indicate 1000 V to 1050 V dc.

5. Read (1) to (4) with selector switch set to 500 V MΩ x 1, 250 V MΩ ÷ 2, and 100 V MΩ ÷ 5.

6. Tabling the above (1) to (5) inclusive:

Selector Switch	Electrostatic voltmeter reading - dc
1000 V MΩ x 2	1000 V to 1050 V
500 V MΩ x 1	500 V to 550 V
250 V MΩ ÷ 2	250 V to 275 V
100 V MΩ ÷ 5	100 V to 110 V

Section 5

TROUBLE-SHOOTING AND MAINTENANCE

5-1 TROUBLE-SHOOTING

5-2 TABLE TROUBLE-SHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
Pointer does not move to infinity when voltage is applied during infinity check.	Defective moving element.	Replace defective moving element assembly. (See paragraph 5-4b.)
	Resistors R_2, R_3, R_4, or R_6 open.	Remove and replace defective resistors. (See paragraph 5-4d.)
	Capacitor C_1 shorted.	Remove and replace defective capacitor. (See paragraph 5-4d.)
	Defective generator assembly.	Remove and replace defective generator assembly. (See paragraph 5-4c.)
	Defective transformer.	Remove and replace. (See paragraph 5-4c.)
Pointer indicates less than infinity when test leads are connected at terminals, with opposite ends separated, and crank is turned at normal speed (160 RPM minimum).	Leakage between test leads.	Correct leakage or replace test leads.

TROUBLE-SHOOTING CHART (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
Pointer does not move promptly to zero when switch is set at:		Remove and replace defective resistors. (See paragraph 5-4d.)
1000 V	Resistor R_8, R_7, R_6, or R_5 open	
500 V	R_7, R_6, R_5 open	
250 V	R_6, R_5 open	
100 V	R_5 open	
Ohm scale Ω	R_{10} open	
	Defective moving element.	Replace defective moving element assembly. (See paragraph 5-4b.)
Pointer does not indicate zero when test lead ends are touched together while ohmmeter is being cranked.	Test leads open circuited.	Correct open circuit or replace test leads.
Pointer indicator does not move readily	Metallic particles collected on moving system magnet.	Collect particles. Exercise extreme care as the moving system can be damaged in the process.

TROUBLE-SHOOTING CHART (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
Ohmmeter does not calibrate	Resistance changes, partial short of resistors, and moving system.	Check resistors and moving system. Replace if defective. (See paragraph 5-4d.)
No generator voltage at GROUND and LINE terminals although crank turns easily.	Defective generator.	Check generator assembly. Remove and replace if defective. (See paragraph 5-4c.)
No generator voltage at GROUND and LINE terminals (crank does not turn easily).	Shorted capacitor C_4.	Replace capacitor. (See paragraph 5-4d.)
	Shorted resistor R_9.	Remove and replace resistor assembly. (See paragraph 5-4d.)
No Output Voltage (Line Operated Sets).	Defective Transformer	Check transformer. Remove and replace if defective. (See paragraph 5-4c.)
	Shorted Capacitor C_4.	Replace capacitor. (See paragraph 5-4d).
	Shorted Resistor R_9.	Remove and replace resistor (See paragraph 5-4d).
	Defective Power Switch S_2.	Remove and replace (See paragraph 5-4e).

5-5 REASSEMBLY OF PARTS AND SUBASSEMBLY

a. REPLACEMENT OF COMPONENT BOARD ASSEMBLY:

(1) Solder new components to component board.

(2) Position component board to chassis with switch lockwasher and nut. (See Figures 6-5C and 6-6A).

(3) Install above completed assembly into case housing and secure with four nuts.

b. REPLACEMENT OF GENERATOR OR TRANSFORMER:

(1) Position generator or transformer on mounting chassis and secure with screws.

(2) Attach leads.

c. REASSEMBLY AND REPLACEMENT OF MOVING ELEMENT ASSEMBLY WITH SCALE.

(1) Position moving element assembly carefully in case housing and secure assembly to chassis with two screws and lockwashers.

(2) Resolder three connections.

d. REPLACEMENT OF CASE COVER.

(1) Position cover on case and secure with four screws.

Section 6

PARTS LIST INFORMATION

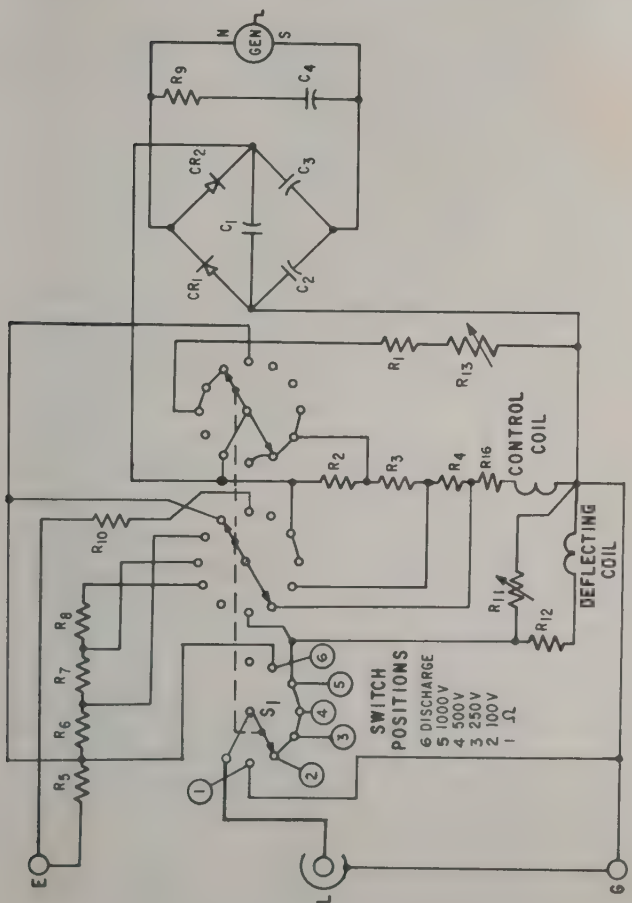


Figure 6-1 - Schematic of Cat. No. 21159 Major Megger Insulation Tester

PARTS LIST INFORMATION (Continued)

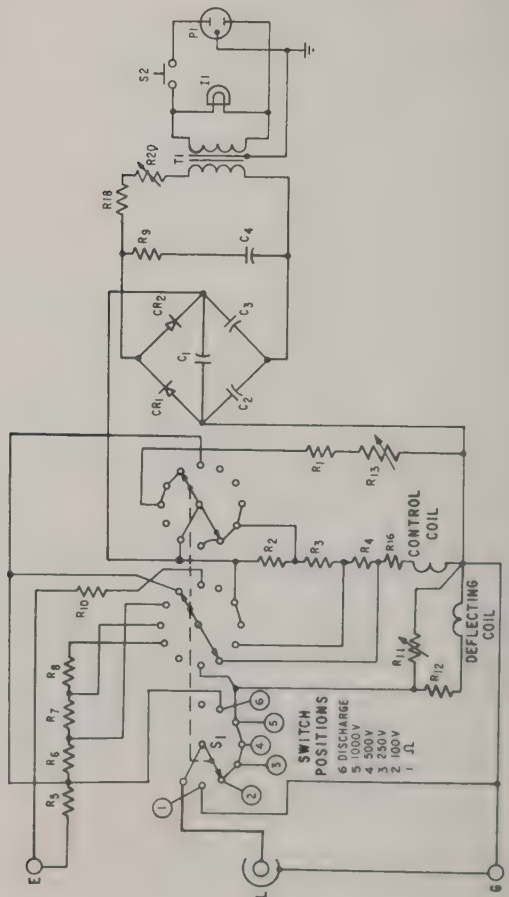


Figure 6-2 - Schematic of Cat. No. 21259 Major Megger Insulation Tester

PARTS LIST INFORMATION (Continued)

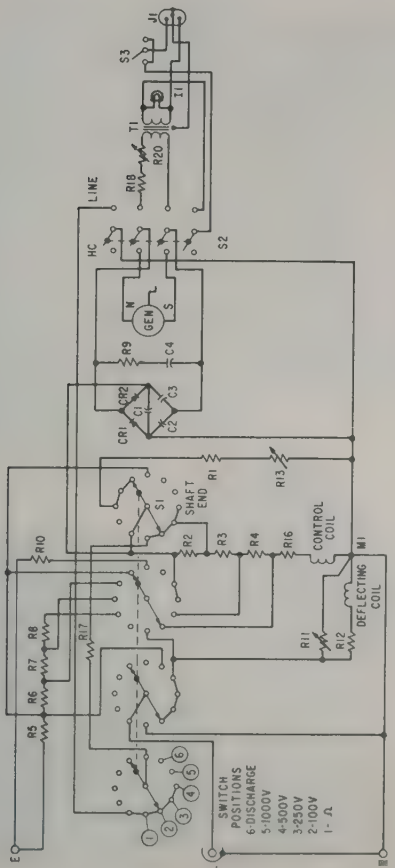


Figure 6-3 - Schematic of Cat. No. 21359 Major Megger Insulation Tester

PARTS LIST INFORMATION (Continued)

Figure 6-4 - Case Bottoms, Bottom Assemblies, Switches, Supply Cords and Transformers.

PARTS LIST INFORMATION (Continued)

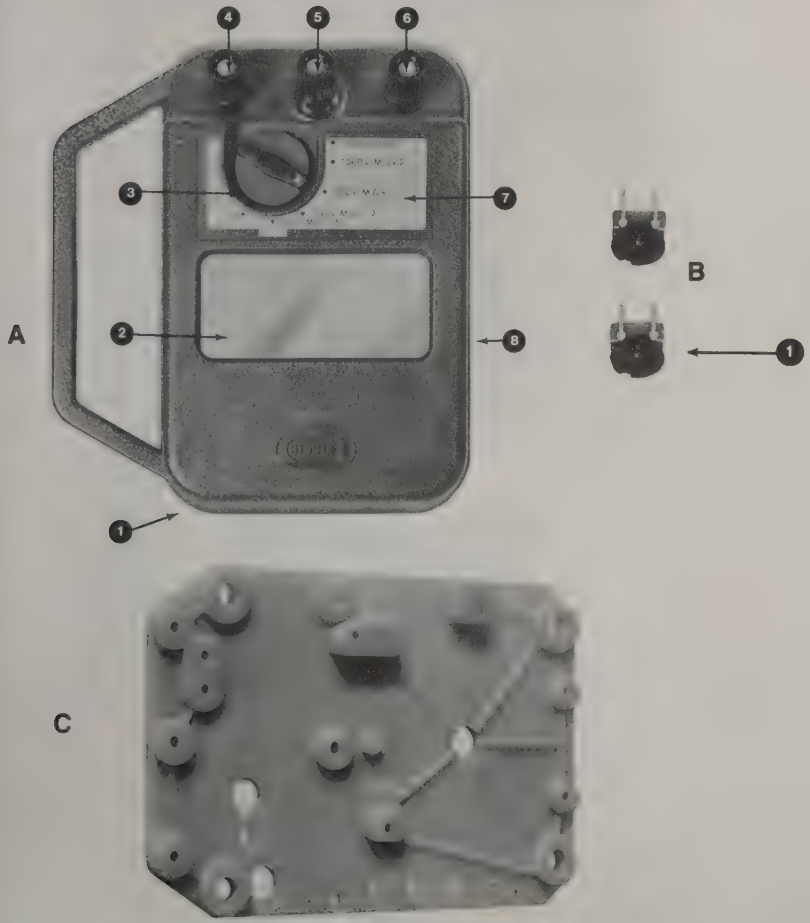


Figure 6-5 - Case Covers, Windows, Binding Posts, Potentiometers and Chassis.

PARTS LIST INFORMATION (Continued)

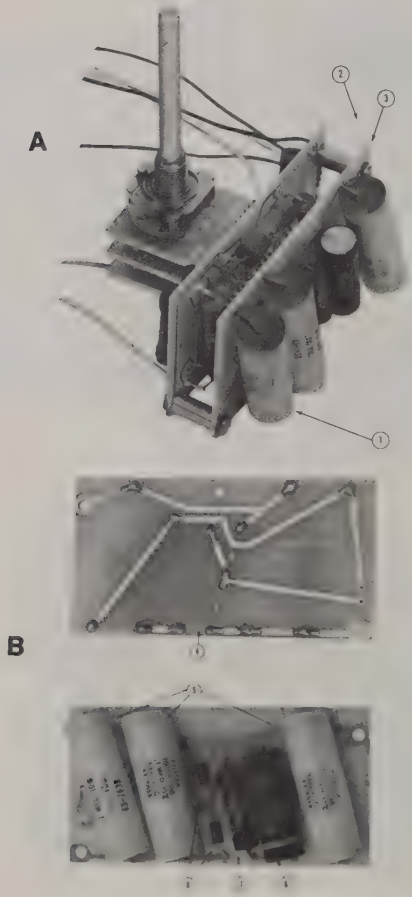


Figure 6-6 - Switch, Component, Rectifier and Range Board Assemblies; also Spacers, Capacitors, Resistor, and Rectifier.

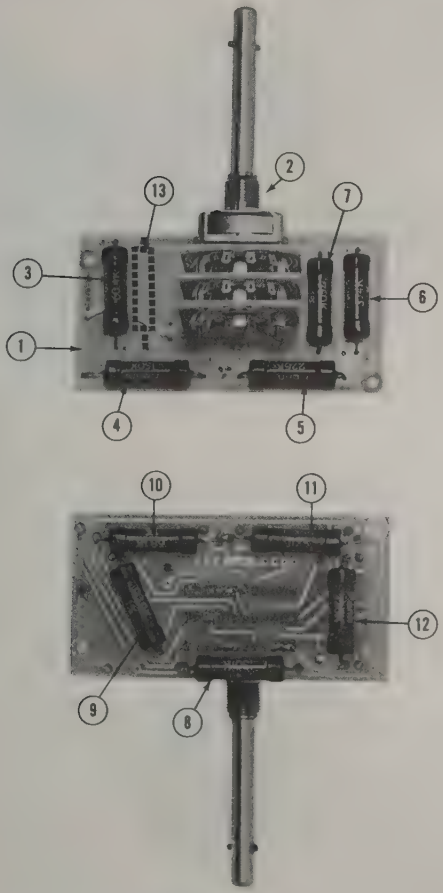


Figure 6-7 - Breakdown of Range Board Assemblies.

PARTS LIST INFORMATION (Continued)

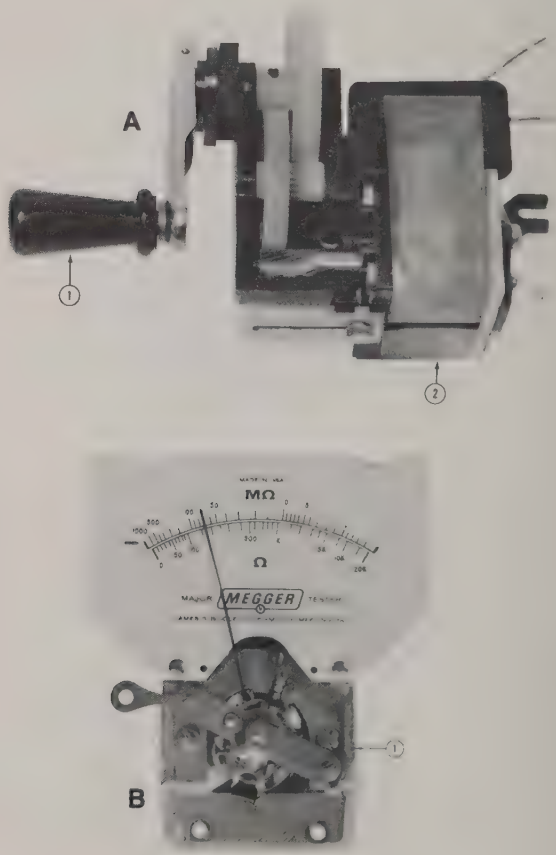


Figure 6-8 - Crank Handle, Generator, Moving System with Scale.

Section 6

PARTS LIST INFORMATION (Continued)

Reference	Call-out Number	Name and Description	Part No.
Figure 6-4			
		For Cat. No. 21159	
A		Bottom	
	1	Bottom only	10438
	2	Feet Rubber (4 required)	5599
		For Cat. No. 21259	
B		Bottom Assembly	10441
	3	Bottom only	10439-1
	2	Feet	5599
	4	Switch	12119-13
	5	Supply Cord	4127-1
	6	Grommet	2967
		For Cat. No. 21259-47	
B		Bottom Assembly	10441-1
	3	Bottom only	10439-1
	2	Feet	5599
	4	Switch	12119-13
	5	Supply Cord	9453
	5a	Supply Cord Plug	9358
	6	Grommet	2967

Section 6

PARTS LIST INFORMATION (Continued)

Reference	Call-out Number	Name and Description	Part No.
Figure 6-4			
		For Cat. No. 21359	
C		Bottom Assembly	10459
	7	Bottom	10439-3
	2	Feet	5599
	8	Switch	12119-13
	9	Switch	12119-8
	10	Receptacle	13339-1
	11	Transformer	4491
		For Cat. No. 21359-47	
		Bottom Assembly	10459-1
	7	Bottom	10439-3
	2	Feet	5599
	8	Switch	12119-13
	9	Switch	12119-8
	10	Receptacle	13339-1
	11	Transformer	4491-1
Figure 6-5			
		For Cat. Nos. 21159,21359,21359-47	
A	1	Case Cover Assembly complete (including window, glass clip and gasket).	4307-9
	2	Window Glass	10432
	-	Window Clip	6364-6
	-	Window Gasket	10433
	3	Range Knob	4337
	4	Binding Post complete - GROUND	11166-2
	5	Binding Post complete - LINE	11166-2
	6	Binding Post complete - GUARD	11166-2
	7	Range Label	4494-6
	8	Case Cover only	10423-1

Section 6

PARTS LIST INFORMATION (Continued)

Reference	Call-out Number	Name and Description	Part No.
Figure 6-5			
		For Cat. Nos. 21259, 21259-47	
A	1	Case Cover Assembly complete (including window, glass clip and gasket).	4307-10
	2	Window Glass	10432
	-	Window Clip	6364-6
	-	Window Gasket	10433
	3	Range Knob	4337
	4	Binding Post complete - GROUND	11166-2
	5	Binding Post complete - LINE	11166-2
	6	Binding Post complete - GUARD	11166-2
	7	Range Label	4494-6
	8	Case Cover only	10423-2
B		Potentiometer (R11 and R13 2 req., Fig. 6-1)	4353-1
C		Chassis	4488-2
Figure 6-6			
A		For Cat. No. 21159	
		Switch and Component Board Assembly	10461-1
	1	Rectifier Board Assembly	10446
	2	Range Board Assembly	10448-1
	3	Spacer, (2 req.)	9379-2
		For Cat. Nos. 21259, 21259-47	
		Switch and Component Board Assembly	10461-2
	1	Rectifier Board Assembly	10446
	2	Range Board Assembly	10448-1
	3	Spacer, (2 req.)	9379-2
		For Cat. Nos. 21359 or 21359-47	
		Switch and Component Board Assembly	10461-3
	1	Rectifier Board Assembly	10446
	2	Range Board Assembly	10483-3
	3	Spacer, (2 req.)	9379-2

PARTS LIST INFORMATION (Continued)

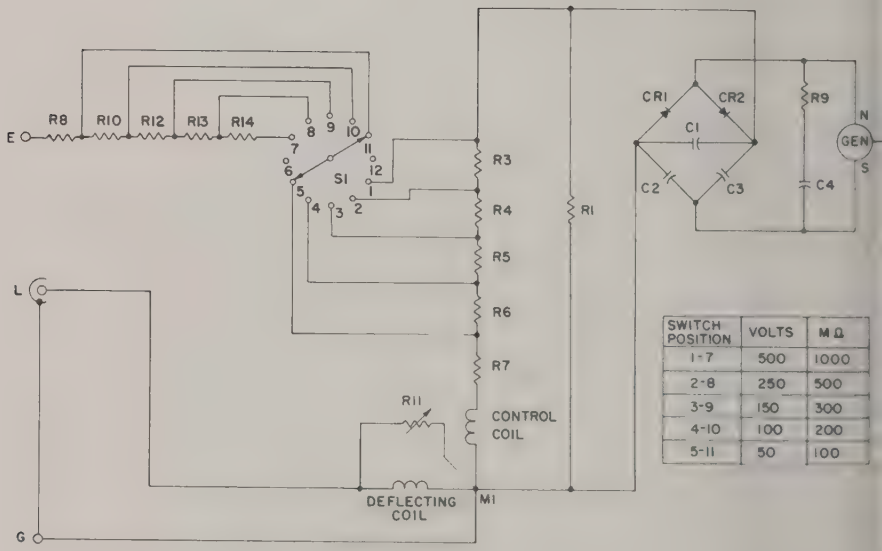
Reference	Call-out Number	Name and Description	Part No.
Figure 6-6		For Cat Nos. 21159, 21259, 21259-47, 21359, 21359-47	
B		Rectifier Board 10446 Breakdown:	
	4	Board	10445
	5	Capacitor	5977-3 C1, C2, C3
	6	Capacitor	5977-4 C4
	7	Resistor	7524-34 R9 82.5 K
	8	Rectifier	5653-2 CR1, CR2

Reference	Figure Number	Name and Description	Part No.
Figure 6-7		Range Board Assembly 10448-1 Breakdown, (See 6-6):	
	1	Board	10447
	2	Switch	10449-2
	3	Resistor	7524-31 (R16 60.4KΩ)
	4	Resistor	7524-16,R3 150K
	5	Resistor	7524-19,R6 226K
	6	Resistor	7524-20,R7,374K
	7	Resistor	7524-21,R8 750K
	8	Resistor	7524-15,R2 301K
	9	Resistor	7524-30,R4 90.9K
	10	Resistor	7524-22,R10 68.1K
	11	Resistor	7524-42,R5 112K
	12	Resistor	7524-19,R1 226K
Figure 6-7		Range Board Assembly 10448-2 Breakdown, (See 6-6):	
	1	Board	10447
	2	Switch	10449-2
	3	Resistor	7524-31 (R16, 60.4KΩ)
	4	Resistor	7524-16,R3 150K
	5	Resistor	7524-19,R6 226K
	6	Resistor	7524-20,R7 374K

PARTS LIST INFORMATION (Continued)

Reference	Figure Number	Name and Description	Part No.
	7	Resistor	7524-21,R8 750K
	8	Resistor	7524-15,R2 301K
	9	Resistor	7524-30,R4 90.9K
	10	Resistor	7524-22,R10 68.1K
	11	Resistor	7524-92,R5 112K
	12	Resistor	4501-413,R1 150K
Figure 6-7		Range Board Assembly 10448-3, (See 6-6):	
	1	Board	10447
	2	Switch	10460-2
	3	Resistor	7524-31(R16 60.4KΩ)
	4	Resistor	7524-16,R3 150K
	5	Resistor	7524-19,R6 226K
	6	Resistor	7524-20,R7 374K
	7	Resistor	7524-21,R8 750K
	8	Resistor	7524-15,R2 301K
	9	Resistor	7524-30,R4 90.9K
	10	Resistor	7524-22,R10 68.1K
	11	Resistor	7524-42,R5 112K
	12	Resistor	7524-19,R1 226K
	13	Resistor	4501-418,R17 180K
Figure 6-8			
A	1	Crank Handle Knob	Z240
	2	Generator Assembly, complete	4333-2
B	1	Moving system, complete with calibrated scale.	10399-1
		Cat. #21359	
		Power Cord	13344
		Lamp 120V	4499-3
		Resistor, R20	6201-17 8K
		Resistor, R18	4501-456 4.7K
		Resistor (all instruments)	7524-17 R12 40K
		Cat. #21259-47 and 21359-47	
		Lamp 240V	4499-4

PARTS LIST INFORMATION
FOR CATALOG NO. 21160



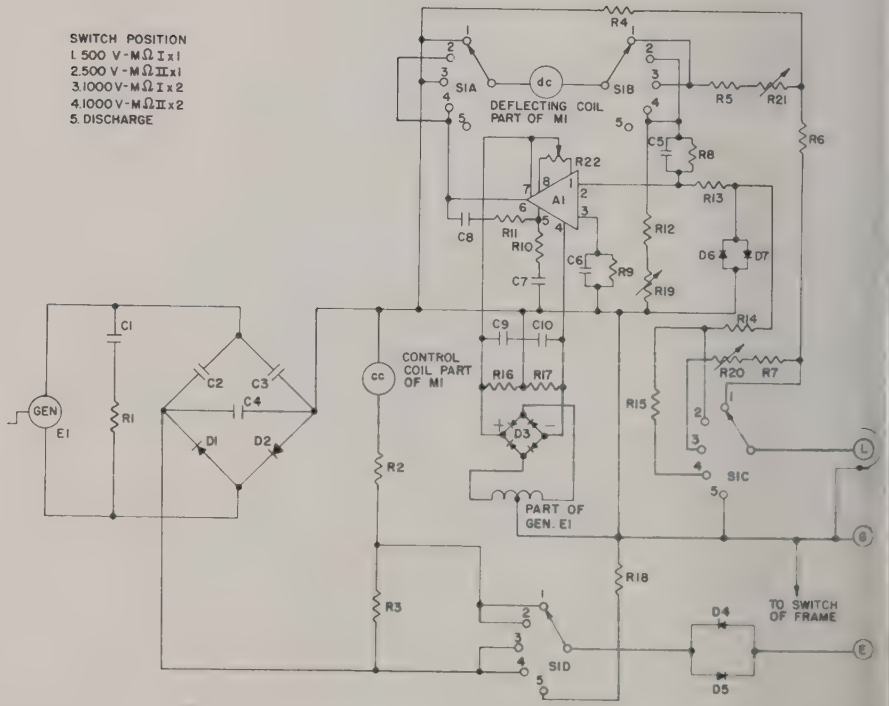
SWITCH POSITION	VOLTS	MΩ
1-7	500	1000
2-8	250	500
3-9	150	300
4-10	100	200
5-11	50	100

Schematic of Cat. No. 21160 Instrument

PARTS LIST INFORMATION
FOR CATALOG NO. 21160

NAME & DESCRIPTION	PART NO.
Generator	4333-2
Moving System complete with calibrated scale	10399-4 M1
Cover Case Assembly	4307-8
Potentiometer	4353-1, 250KΩ, R11
Switch	1524-1
Component Board Assembly	5163
Capacitor	5977-4, .033μF, 600V, 5%, C4
Capacitor	5977-3, 0.1μF, 1000V, 10%, C1, C2, C3
Diode	5653-2, 2000PIV, .25mA, CR1, CR2
Resistor	7524-14, 392KΩ, 1W, 1%, R1
Resistor	7524-16, 150KΩ, 1W, 1%, R3, R13
Resistor	7524-31, 60KΩ, 1W, 1%, R4
Resistor	7524-35, 30KΩ, 1W, 1%, R5, R6, R7
Resistor	7524-41, 75KΩ, 1W, 1%, R8, R10, R12
Resistor	7524-34, 82.5KΩ, 1W, 1%, R9
Resistor	7524-20, 374KΩ, 1W, 1%, R14

PARTS LIST INFORMATION
FOR CATALOG NO. 21170

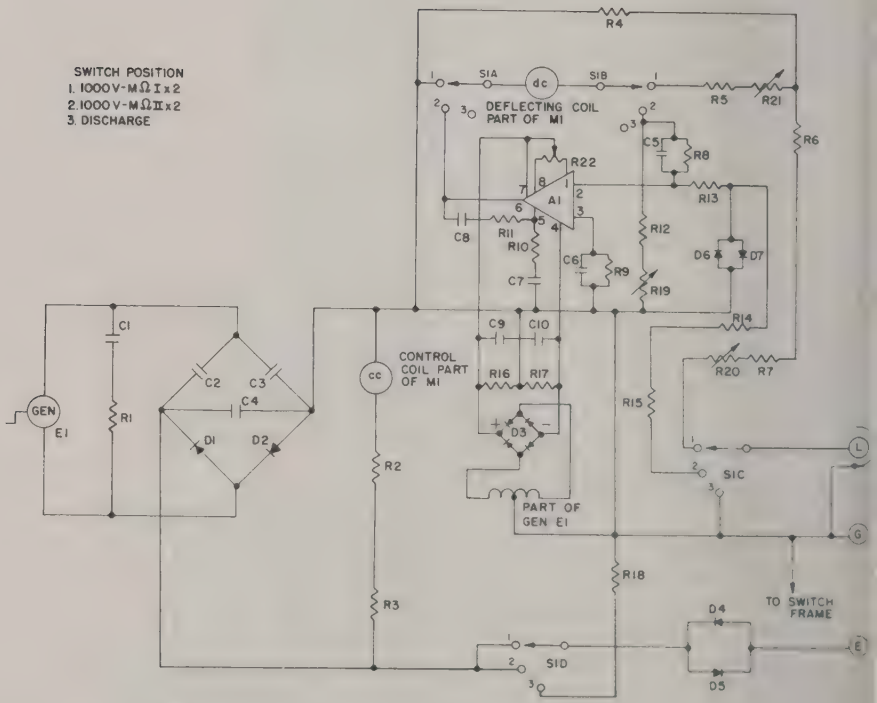


Schematic of Cat. No. 21170 Instrument

PARTS LIST INFORMATION FOR CATALOG NO. 21170

NAME & DESCRIPTION	PART NO.
Generator	4333-3 E1
Moving System complete with calibrated scale	10399-6 M1
Cover Case Assembly	4307-12
Capacitor	5977-5, 0.47μF, 1000V, 10% C4
Potentiometer	5183-1, 250Ω, R19
Potentiometer	5183-2, 1KΩ, R21
Potentiometer	5183-3, 25K, R20
Potentiometer	5183-4, 100K, R22
Switch Assembly	5184
Switch	5185-2 S1
Resistor	7524-32, 100KΩ, 1W, 1%, R18
Resistor	7524-15, 20K, 1W, 1%, R15
Basic Board Assembly	5181
Capacitor	5977-2, 0.05μF, 600V, 5%, C1
Capacitor	5977-3, 0.1μF, 1000V, 10%, C2, C3
Diode	5653-2, 2000PIV, .25mA, D1,D2,D4,D5
Resistor	7524-22, 68KΩ, 1W, 1%, R1
Resistor	7524-14, 392KΩ, 1W, 1%, R2, R3
Resistor	7524-36, 750Ω, 1W, 1%, R4
Resistor	7524-37, 1.8KΩ, 1W, 1%, R5
Resistor	7524-10, 50KΩ, 1W, 1%, R6, R7
Amplifier Board Assembly	5182
Capacitor	12024-1, 1μF, 50V, 10%, C5, C6
Capacitor	4559-5, 0.047μF, 200V, 10%, C7
Cpacitor	4559-25, 0.027μF, 100V, 10%, C8
Capacitor	12019-5, 47μF, 20V, 10%, C9, C10
Rectifier Bridge	14043-1, 100V, 1A, D3
Diode	11637-6 1N914 D6, D7
Resistor	11445-74, 51.1KΩ, 1/2W, 1%, R8, R9
Resistor	4501-106, 10Ω, 1/2W, 5%, R10
Resistor	4501-179, 39Ω, 1/2W, 5%, R11
Resistor	11445-62, 806Ω, 1/2W, 1%, R12
Resistor	11445-9, 10kΩ, 1/2W, 1%, R13
Resistor	11445-50, 20KΩ, 1/2W, 1%, R14
Resistor	11445-4, 1KΩ, 1/2W, 1%, R16
Resistor	8317-40, 33KΩ, 1/2W, 1%, R17
Amplifier	13194 LM312H A1

PARTS LIST INFORMATION
FOR CATALOG NO. 21171



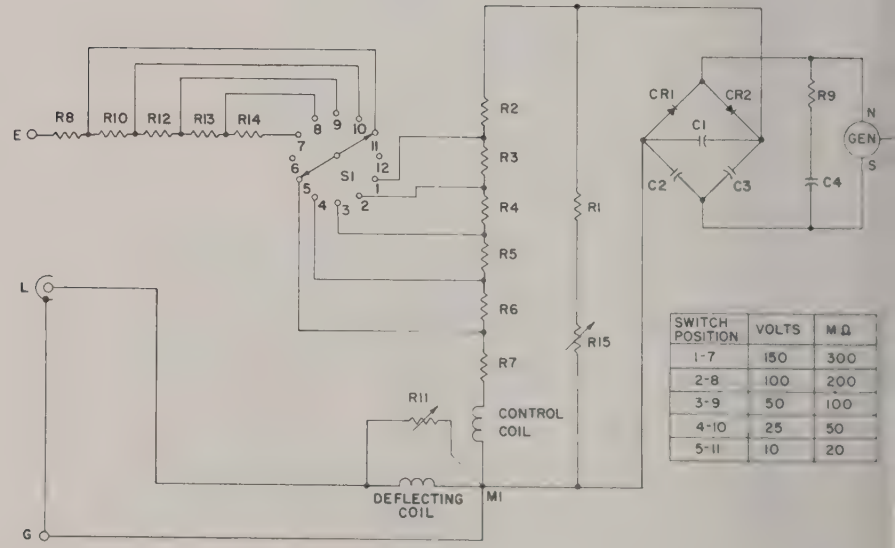
Schematic of Cat. No. 21171 Instrument

PARTS LIST INFORMATION

FOR CATALOG NO. 21171

NAME & DESCRIPTION	PART NO.
Generator	4333-3 E1
Moving System complete with calibrated scale	10399-6 M1
Cover Case Assembly	4307-12
Capacitor	5977-5, 0.47µF, 1000V, 10% C4
Potentiometer	5183-1, 250Ω, R19
Potentiometer	5183-2, 1KΩ, R21
Potentiometer	5183-3, 25K, R20
Potentiometer	5183-4, 100K, R22
Switch Assembly	10444
Switch	1524-2 S1
Resistor	7524-32, 100KΩ, 1W, 1%, R18
Resistor	7524-15, 20K, 1W, 1%, R15
Basic Board Assembly	5181
Capacitor	5977-2, 0.05µF, 600V, 5%, C1
Capacitor	5977-3, 0.1µF, 1000V, 10%, C2, C3
Diode	5653-2, 2000PIV, .25mA, D1,D2,D4,D5
Resistor	7524-22, 68KΩ, 1W, 1%, R1
Resistor	7524-14, 392KΩ, 1W, 1%, R2, R3
Resistor	7524-36, 750Ω, 1W, 1%, R4
Resistor	7524-37, 1.8KΩ, 1W, 1%, R5
Resistor	7524-10, 50KΩ, 1W, 1%, R6, R7
Amplifier Board Assembly	5182
Capacitor	12024-1, 1µF, 50V, 10%, C5, C6
Capacitor	4559-5, 0.047µF, 200V, 10%, C7
Cpacitor	4559-25, 0.027µF, 100V, 10%, C8
Capacitor	12019-5, 47µF, 20V, 10%, C9, C10
Rectifier Bridge	14043-1, 100V, 1A, D3
Diode	11637-6 1N914 D6, D7
Resistor	11445-74, 51.1KΩ, 1/2W, 1%, R8, R9
Resistor	4501-106, 10Ω, 1/2W, 5%, R10
Resistor	4501-179, 39Ω, 1/2W, 5%, R11
Resistor	11445-62, 806Ω, 1/2W, 1%, R12
Resistor	11445-9, 10kΩ, 1/2W, 1%, R13
Resistor	11445-50, 20KΩ, 1/2W, 1%, R14
Resistor	11445-4, 1KΩ, 1/2W, 1%, R16
Resistor	8317-40, 33KΩ, 1/2W, 1%, R17
Amplifier	13194 LM312H A1

PARTS LIST INFORMATION
FOR CATALOG NO. 21189



SWITCH POSITION	VOLTS	MΩ
1-7	150	300
2-8	100	200
3-9	50	100
4-10	25	50
5-11	10	20

Schematic of Cat. No. 21189 Instrument

PARTS LIST INFORMATION
FOR CATALOG NO. 21189

NAME & DESCRIPTION	PART NO.
Generator	4333-2
Moving System complete with calibrated scale	10399-4 M1
Cover Case Assembly	4307-7
Potentiometer	4353-1, 250KΩ, R11, R15
Switch	1524-1 S1
Component Board Assembly	12460
Capacitor	5977-4, .033μF, 600V, 5%, C4
Capacitor	5977-3, 0.1μF, 1000V, 10%, C1, C2, C3
Diode	5653-2, 2000PIV, .25mA, CR1, CR2
Resistor	7524-14, 392KΩ, 1W, 1%, R1
Resistor	7524-38, 210KΩ, 1W, 1%, R2
Resistor	7524-35, 30KΩ, 1W, 1%, R3, R4
Resistor	7524-25, 9KΩ, 1W, 1%, R6
Resistor	7524-39, 11KΩ, 1W, 1%, R8
Resistor	7524-34, 82.5KΩ,1W, 1%, R9
Resistor	7524-40, 24KΩ, 1W, 1%, R10
Resistor	7524-17, 40KΩ, 1W, 1%, R12
Resistor	7524-41, 75KΩ, 1W, 1%, R13, R14
Resistor	8317-28, 15KΩ, 1/2W, 1%, R5
Resistor	11445-40, 6040Ω, 1/2W, 1%, R7

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